Upcoming Common Inspection Criteria on

Power supply, utilities and blackouts

Presentation on lessons learned study of chemical incidents involving power failures

Kostas Koutelos
JRC - MAHB

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Lessons Learned study on power failures

The 15th Lessons Learned Bulletin focuses on industrial incidents originating from power supply failures

- Analysis of 90 chemical incidents from multiple industrial sectors
- Exploiting various chemical accident data sources such as
    - eMARS
    - ARIA
    - U.S. Chemical Safety Board
    - ZEMA
    - The Institution of Chemical Engineers (IChemE)
    - The Japanese Failure Knowledge Database

To extract lessons learned on the:

- Prevention of power failures
- Prevention of loss of containment and mitigation practices following a power failure

Available at:
https://minerva.jrc.ec.europa.eu/en/shorturl/minerva/llb15power_failures_final

Power failure and chemical accidents

- Uninterrupted power supply is life-essential for chemical plants to refineries, warehouses and other downstream users
- In 2018 industrial consumption of electricity accounted for the 42% of worldwide consumption*.
- Important to productivity, business continuity but also **process safety**

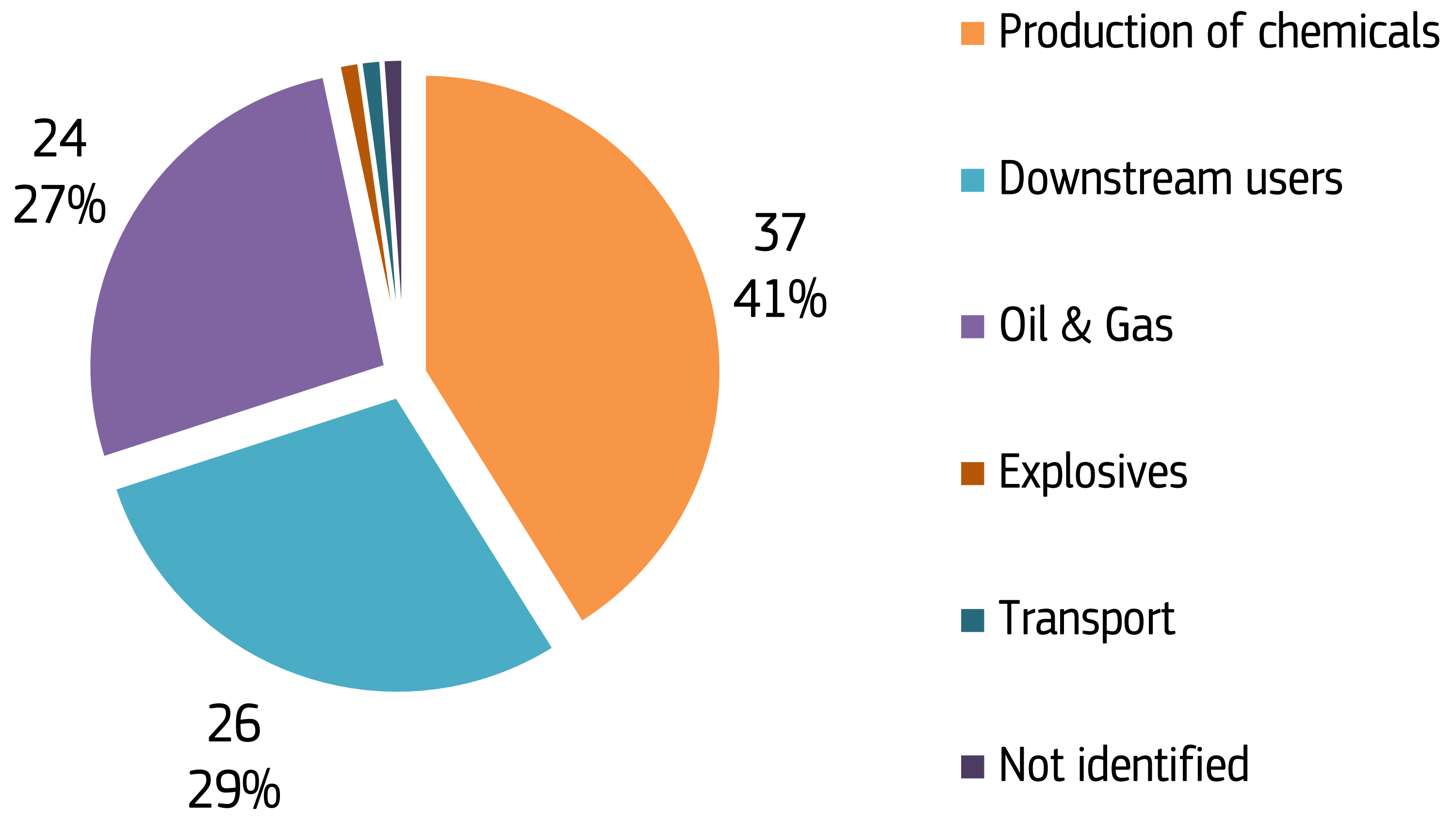
  - ➢ What is the contribution of power failures to chemical accidents?
  - ➢ How can we support risk assessment and management decisions associated with potential accident scenarios involving power failures?

Dissemination of good enforcement and risk management practices for the control of major industrial hazards

**International Energy Agency. Electricity Information: Overview. https://www.iea.org/reports/electricity-information-overview (2020).*

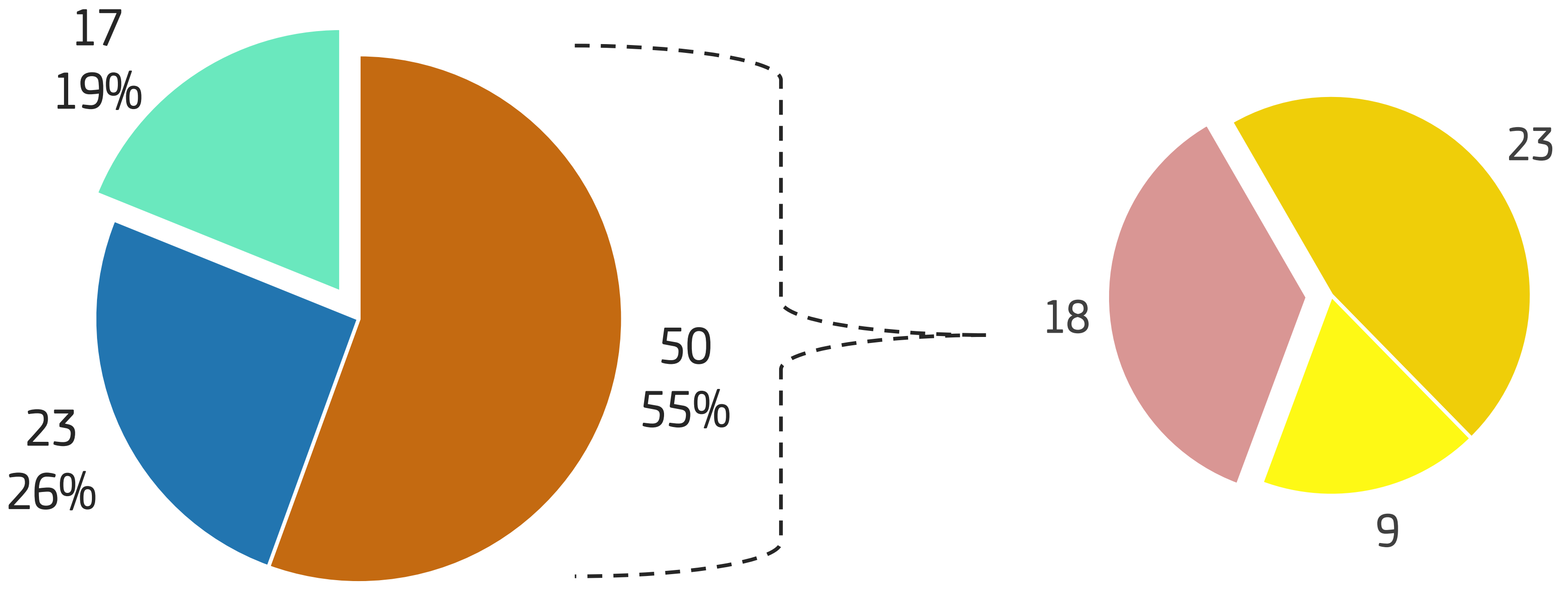
Incidents and associated industries

Analysis of 90 incidents



Phenomena produced

Analysis of 90 incidents



Release of toxic substances

Formation of toxic cloud

Release of flammable substances

Release of flammable and/or toxic substances

Explosion and/or fire

Near miss/No phenomena produced

Importance of power failure accidents

Release of hydrogen sulphide in Antwerp, Belgium
September 2, 2008

- Loss of power supply during maintenance
- Release of 70 kilograms of hydrogen sulphide (pure H_2S gas) through safety valves
- Formation of toxic cloud travelling through Belgium and the Netherlands
- **Hundreds of people were affected, 57 sought medical attention**

Release of ammonia in Alabama, United States
August 23, 2010

- Loss of power supply followed by erroneous operator action
- Release of over 14t of anhydrous ammonia following piping hydraulic shock and rupture
- Formation of toxic cloud
- **More than 140 offsite personnel exposed, 32 requiring hospitalisation and 4 intensive care**

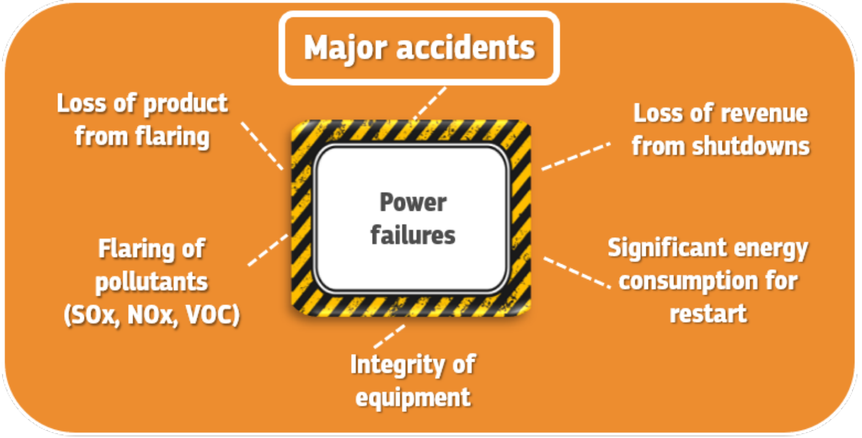
Importance of power failure accidents

Repsol refinery explosion in Puertollano, Spain
August 13, 2003

- **9 Fatalities and 10 injuries**
- Significant material damage
- Over 54 million euros in material losses and restoration costs
- Offsite water supply disrupted for 4 hours
- Main roads around the refinery were closed for 76 hours

"Tres muertos al incendiarse la refinería de Puertollano", EL PAIS
https://elpais.com/diario/2003/08/15/portada/1060898404_850215.html

Power failure characteristics



- Usually unpredictable (i.e. weather conditions or public supply failures)
- Can affect multiple units and equipment (common mode failure)
- May have delayed consequences contributing to a loss of containment
- Power failures can affect the majority, if not all, industries

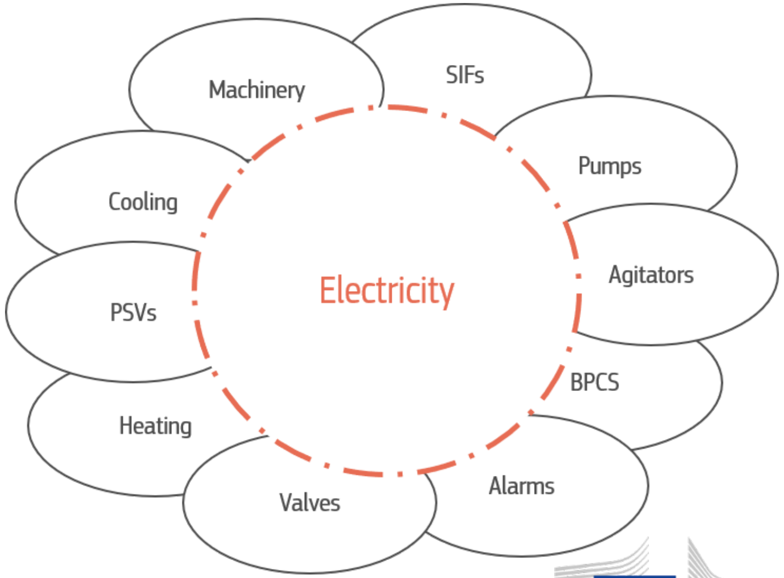
How a power failure can cause loss of containment

Following a power loss, an industrial site will go into one of the following modes:

- A **planned shutdown** with the support of UPS
- A **controlled emergency shutdown** with the support of UPS, if the backup power supply fails
- An **uncontrolled emergency shutdown** (partially or complete), If the backup power supply fails
- Following the shutdown (planned or unplanned) the site or specific processes will start up again; **recovery**

The outcome of the event of power failure relies heavily on:

- ➢ Whether processes or equipment were affected
    - ➢ Which were affected?
        - ➢ How were they affected?



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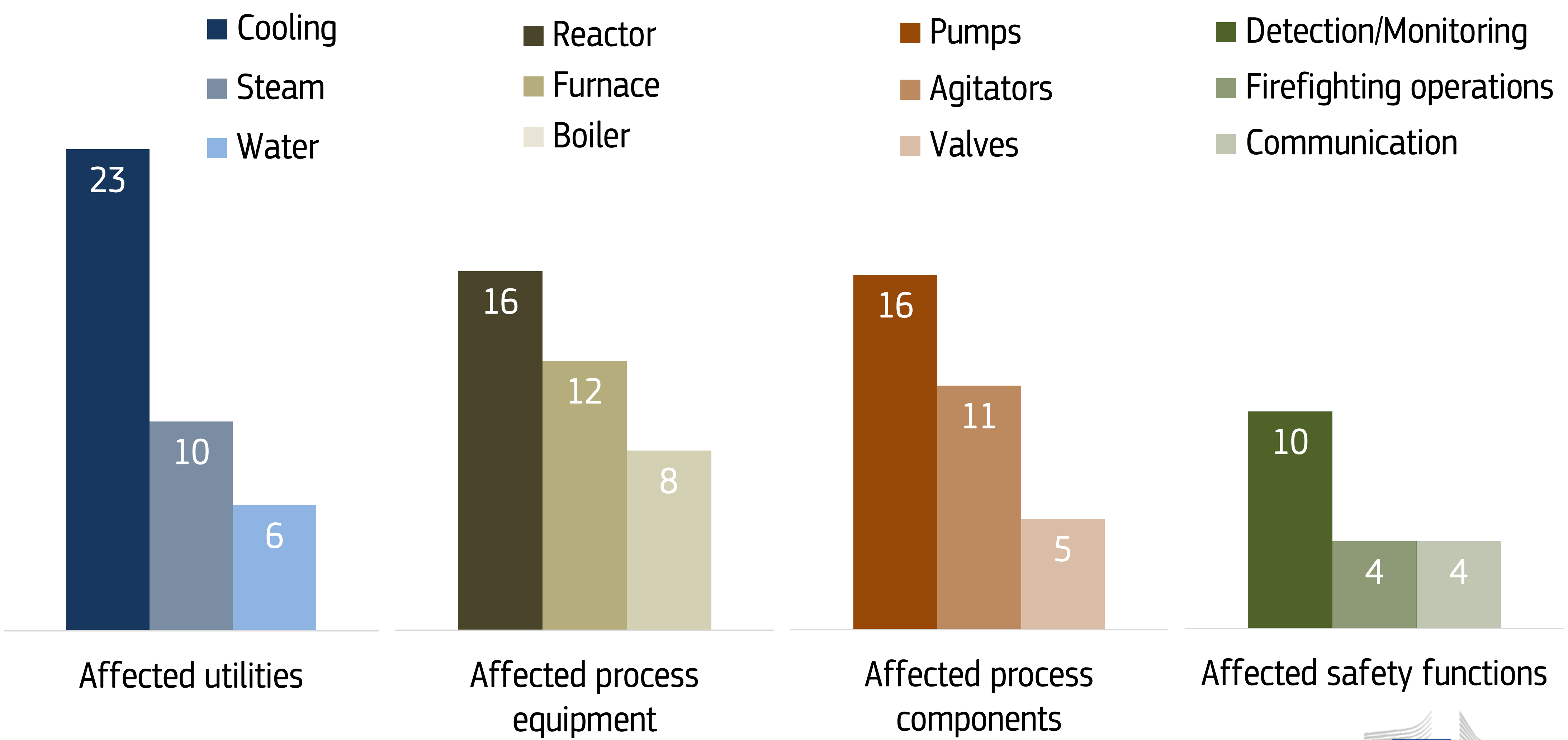
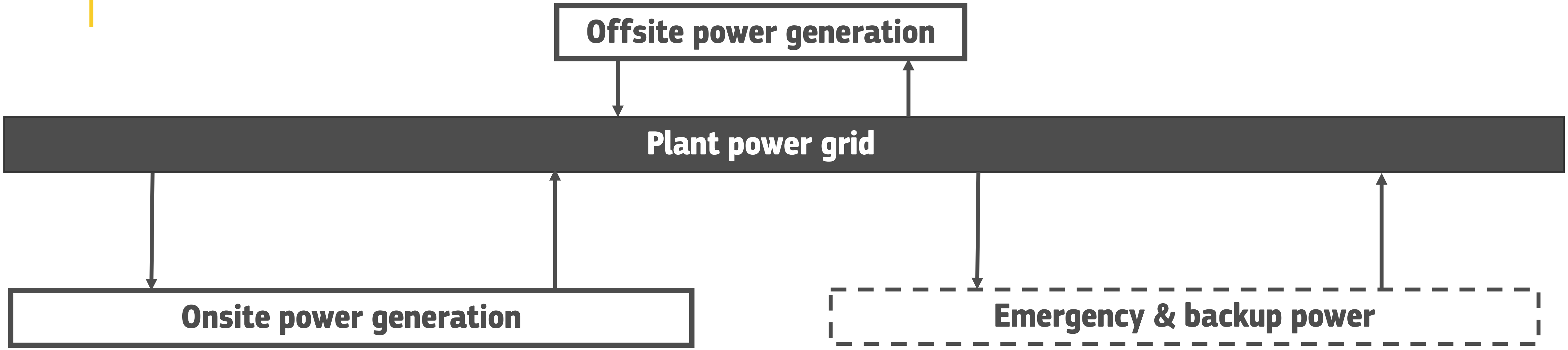
Impact on facilities

Analysis of 90 incidents



Power generation



Cogeneration

Steam powered generators using the waste energy

Microgrids

Small scale version of a centralized electricity system

Uninterruptible power supply (UPS)

- Short duration - Battery powered
- Maintain power to critical control circuits/instruments to facilitate shutdown
- Switching between power feeds
- Cover power break due to generators lag

Generators

- Diesel
- Natural gas
- Liquified Petrol
- Dual or bi-fueled

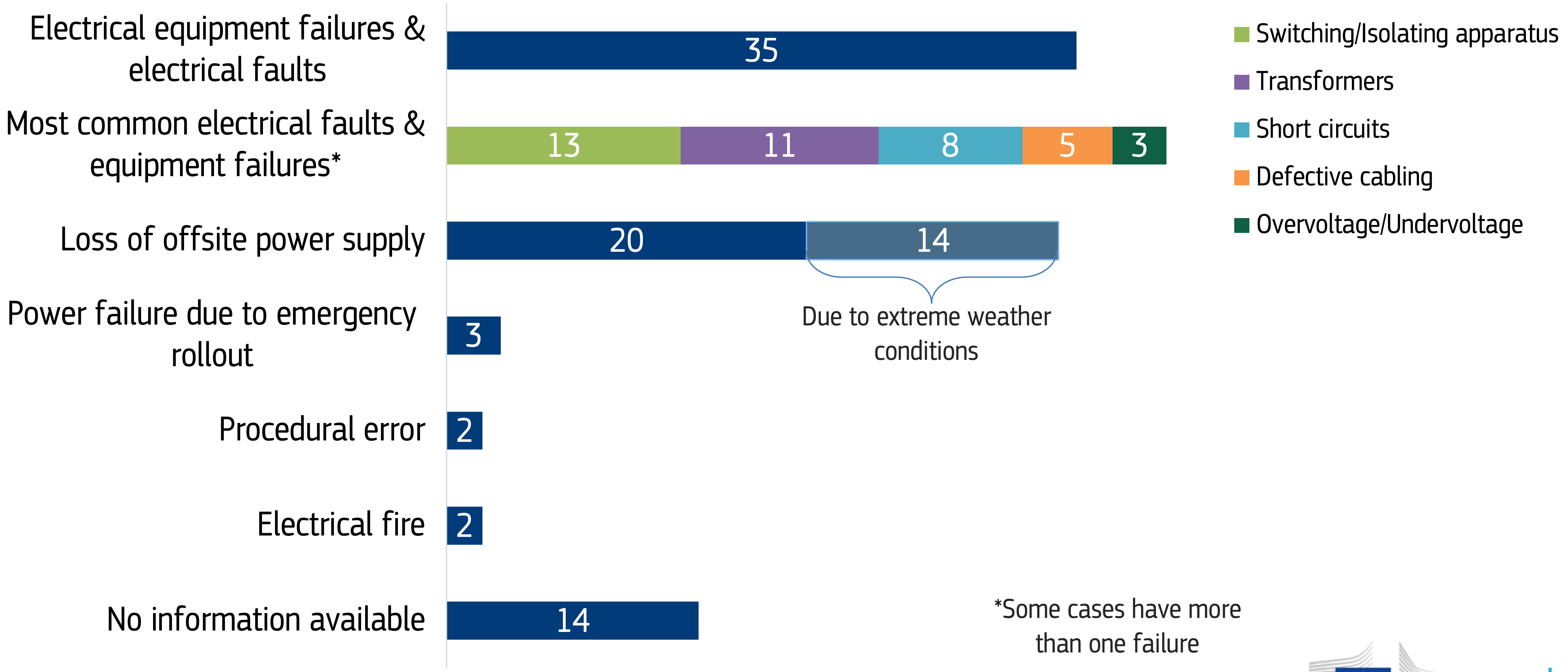
Blackouts and brownouts

- Complete loss of power
- Induced by damaged equipment, extreme weather conditions or grid exceeding supply limit
- Usually unexpected
- Affects all equipment
- Can last for a few minutes to days

- Partial outage
- Voltage fluctuation typically imposed by utility companies to avoid a blackout
- Usually planned
- Affects sensitive electronic equipment
- Can last for a few seconds to hours

Causes of primary power failure

Analysis of 90 incidents



*Some cases have more than one failure

Failures in the redundant power supply

Analysis of 90 incidents

Redundant systems were found to be unavailable upon request (failure on demand) or became unavailable shortly after being activated in 33 cases (37%), leading to unsuccessful recovery from the primary power failure

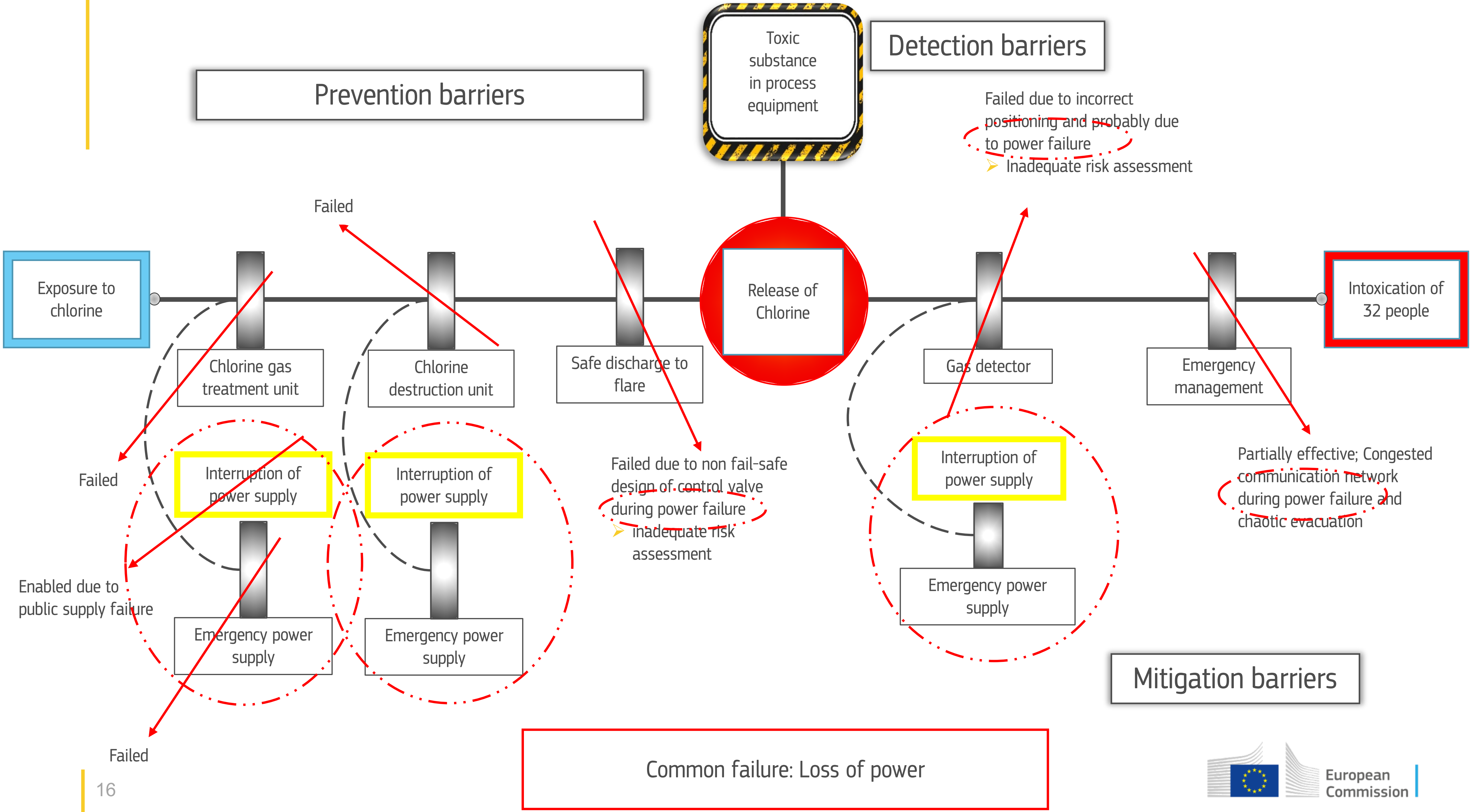
Typical failures included:

- Failure of **onsite generators** (whether steam or fossil-fuelled)
- Failure in the **switching operation** between the primary power supply and the available backup systems
- Failure of the **UPS** systems
- Other common **faults**, such as short circuits, and overvoltage or undervoltage

Case study

Release of chlorine in a chemical plant as consequence of failure of the public power supply, Netherlands 1991

- Chemical plant processing chlorine under normal operation
  - Temporary power loss due to momentary interruption of public power supply
- Chlorine should have been directed to the scrubbing system for destruction through a vacuum created by two fans
  - Emergency power supply failure on demand
  - Fans stopped due to lack of energy source
  - Route to the flare was blocked since the control valve regulating the flow was designed to be closed during a power failure
  - Around 120kg of chlorine released at ground level
- The emission went unnoticed and no gas alarm was sounded because the chlorine passed under the chlorine detection system; it may also have been inoperable due to lack of electricity
  - 32 employees of nearby facility were affected by the toxic cloud and notified the chemical plant
  - The evacuation was described as chaotic while communication networks were congested; it took the operator nearly 8 minutes to inform the authorities of the release because the telephone network was also overloaded due to the general power failure.



Toxic substance in process equipment
Detection barriers
Prevention barriers
Failed due to incorrect positioning and probably due to power failure
Inadequate risk assessment
Failed
Exposure to chlorine
Chlorine gas treatment unit
Chlorine destruction unit
Safe discharge to flare
Release of Chlorine
Gas detector
Emergency management
Intoxication of 32 people
Interruption of power supply
Interruption of power supply
Interruption of power supply
Failed
Failed due to non fail-safe design of control valve during power failure
inadequate risk assessment
Partially effective; Congested communication network during power failure and chaotic evacuation
Enabled due to public supply failure
Emergency power supply
Emergency power supply
Emergency power supply
Mitigation barriers
Failed
Common failure: Loss of power

Lessons Learned

- A solid **inspection and maintenance plan** is critical to ensure the reliability and availability of backup systems.
- The **risk assessment** should take into account possible failure of the backup power supply and ensure the adequacy of detection systems as well as the design of the fail-safe positions of control valves.
- Local authorities and relevant stakeholders should establish **emergency protocols** facilitating communication during crises.

Strengthening prevention and mitigation barriers

- To avoid any loss of containment and to mitigate its effect, **barriers have to remain active**
- Failure of redundancy will allow the **propagation of electrical disruption**
- Restarting of operations or transition to safe state following a power failure will require **once again** the uninterrupted power supply
- Uninterrupted power supply is crucial even **post-release** to control potential LOC and support emergency operations

Role of inspections

The facility's response to the power failure will determine to a great extent the outcome of an accident scenario. Hence it is important to assess during inspection:

The availability and reliability of power supply, switchover systems and redundant power sources

The fitness of installations and operating equipment in the event of a power supply failure

Key points for **inspection**

- **Risk assessment and power failure scenarios**
- **Inspection and test plan**
- **Pressure relief**
- **Safety critical functions**
- **Personnel training**
- **Backup requirements and availability**
- **Emergency protocols for communication**

Scope of the upcoming CIC

- Power supply to process establishments and types of power sources
- Purpose of power supply
- Types of power failures
- Critical utilities
- Preventing electrical faults
- Independence and redundancy of power supply
- Switchover mechanisms
- Weather and operating conditions affecting power supply
- Safety Instrumented Functions
- Functionality and availability of flushing and overpressure relief systems
- Communication during loss of power supply
- Training and emergency preparedness
- Transitioning to safe state and mechanical integrity
- Preparing for safe recovery

Thank you for your attention!

Questions?

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